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Eastern Pacific Expeditions of the New York Zoological Society. XXXVII. Deep-sea Ceratioid Fishes¹.

WILLIAM BEEBE & JOCELYN CRANE.

Department of Tropical Research, New York Zoological Society.

(Plates I-III. Text-figures 1-19.)

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[This is the thirty-seventh of a series of papers dealing with the collections of the Eastern Pacific Expeditions of the New York Zoological Society made under the direction of William Beebe. The present paper is concerned with specimens taken on the Arcturus Oceanographic Expedition (1925), the Templeton Urocker Expedition (1936) and the Eastern Pacific Zaca Expedition (1937-1938). For data on localities, dates, nets, etc., refer to Zoologica, Vol. VIII, No. 1, pp. 1-22; Vol. XXII, No. 2, pp. 33-46; and Vol. XXIII, No. 14, pp. 287-298.]

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INTRODUCTION.

The twenty-four species discussed in this paper include ten forms apparently new. In addition, a group of ten free-swimming linophrynid males are referred to *Acceratias* spp. because the inadequacy of present knowledge makes further division too tentative to be practicable. Rather, it seems more profitable to treat the group as a unit, suggesting the use of various hitherto unused characters as indices of either growth stages or specific distinctions.

¹ Contribution No. 745, Department of Tropical Research, New York Zoological Society.

With the possible exception of several *Dolopichthys,* the only specimens young enough to be referable to post-larvae and young adolescents are a few of these Aceratias. The indications of youth are very similar to those found in corresponding stages of other deep-sea fish previously studied (See especially Zoologica, Vol. XVI, No. 1, 1933, general discussion; and *Zoologica*, Vol. XXIV, No. 6, 1939, Melanostomiatids). The post-larvae are distinguished by the general character of imperfectly differentiated pectorals and/or the remains of larval finfolds and by the persistence of apparently larval teeth. Typically male ceratioid characters of this stage are great inflation of the dermal envelope, almost normal eyes and small nostrils.

Adolescence is distinguished by the general characters of disappearance of true finfolds and complete differentiation of pectorals, and by the male ceratioid characters of reduced inflation, eyes gradually revolving forward and down, expansion of nostrils, and the beginning of gonad growth.

The majority of the ceratioids in this paper, as usual in deep-sea fish collections, are transitional adolescents. That is, they are in the long period of pre-adult growth where practically adult appearance has been assumed, but with immaturity shown internally by the small size of the gonads and, in the case of males of parasitic families, by the non-degenerate digestive organs. Only two attached males were taken, each found on a large *Borophryne apogon*. Since both sexes of one pair were found to be very immature internally, attachment obviously cannot strictly speaking be called an indication of adulthood.

We wish to emphasize here the necessity of examining the internal organs of ceratioids, in order that growth characters may eventually be properly distinguished from those of taxonomic importance.

The field notes on color and luminescence were all made by the senior author on freshly caught specimens, only a few minutes after their removal from the net. In some cases, always specially mentioned in the text, the fish were still living.

FAMILY MELANOCETIDAE.

Melanocetus ferox Regan, 1926.

Reference: Melanocetus ferox Regan, 1926, p. 33, pl. ix, fig. 1; Regan & Trewavas, 1932, p. 52, text-fig. 75.

Range: Eastern Pacific; Gulf of Panama. The present specimens are the first taken outside the Gulf.

Specimens Taken by the Eastern Pacific Expeditions: Two specimens, from 300 and 500 fathoms, off Costa Rica and Galápagos Islands, respectively; lengths 33.5 (22+ 11.5) mm. and 23.5 (15+8.5) mm.; young transitional adolescents.

Color (living specimens): Smaller brownish-black, larger pale brown; all fins, eye sockets, gill openings and illicium stem colorless to grayish-white; bulb black in smaller, dark blue in larger; envelope and distal, conical projection translucent white in smaller, translucent and colorless in larger.

Luminescence: The illicium bulb of the smaller fish gave off two weak flashes of whitish light in the dark room, when a few drops of weak formalin were added to the water. Both fishes died within a few minutes of capture.

Measurements: 23.5 mm. specimen: mandible 9.9 mm.; interorbital width 3.8; postorbital width 9.6; illicium length 6.4; longest fang 1.6. 33.5 mm. specimen: mandible 16.5 mm.; interorbital width 4.8; postorbital width 7.8; illicium length 9; longest fang 2.5. Fins: Pectoral 19; dorsal 15; anal 4.

Remarks: These young fish, both of which are smaller than any of the three previously taken, differ from the latter chiefly in the teeth, which, as was to be expected, are weaker and smaller in the jaws and lacking on the vomer. It is interesting that the 23.5 mm. specimen had the pigment more highly developed than the 33.5 mm. example; in other respects, however, the larger was the more advanced.

Study Material: Cat. No. 6338; Arcturus Oceanographic Expedition; Sta. 86 T-8; 16 miles S.W. of Narborough I., Galápagos (0°42' N. Lat., 91°47' W. Long.); 500 fathoms; June 12, 1925; length 23.5 (15+8.5) mm.

Cat. No. 28,489; Eastern Pacific Zaca Expedition; Sta. 219 T-1; 25 miles $W \times N$ of Pt. Burica, Costa Rica (8°08' N. Lat., 83°17' W. Long.); 300 fathoms; March 10, 1938; length 33.5 (22+11.5) mm.

Melanocetus johnsoni Gunther, 1864.

References: Melanocetus johnsoni Gunther, 1864, p. 301, pl. xxv; Regan & Trewavas, 1932, p. 50, figs. 72, 73.

Range: North Atlantic, Caribbean, Indian and Pacific Oceans. The present specimen extends the known Pacific range about 2,160 miles to the east. Specimen Taken by the Eastern Pacific Expeditions: One specimen, Cat. No. 28,628; Station 227 T-1, Eastern Pacific Zaca Expedition; 20 miles southwest of Morro de Puercos, Panama (7°0' N. Lat., 80°40' W. Long.); 500 fathoms; March 21, 1938; length 46 (31+15) mm.; transitional adolescent with ovaries feebly developed.

Color (fresh specimen): Body brownishblack; fins white; illicium stem pigmented light brown, increasingly darker up to and around bulb; crest above bulb white with distal tubercle pigmented brown; peritoneum jet black.

Measurements: Illicium 12.5 mm.; mandible 21; interorbital width 5.6; postorbital head width 13.

Fins: Pectoral 20; dorsal 15; anal 4.

Food: Well digested, small myctophids.

Remarks: This specimen agrees perfectly with those of similar size described by Regan & Trewavas (1932).

Melanocetus megalodontis sp. nov.

(Text-fig. 1).

TYPE.

(The unique specimen).

Department of Tropical Research No. 25,791; Templeton Crocker Expedition of the New York Zoological Society; Sta. 165 T-3; May 17, 1936; 500 fathoms; 145 miles north of Clarion Island (20° 36' N. Lat., 115° 07' W. Long.); total length 38.5 (27+11.5) mm.; a transitional adolescent with small ovaries.

DESCRIPTION.

With the characteristics of the genus.

Color (fresh specimen): Dark brownishblack; all fins and stem of illicium colorless; major illicium bulb blue-black, its translucent envelope and minor bulb colorless; peritoneum jet black.

Measurements and Proportions: Total length 38.5 (27+11.5) mm.; illicium length 13.5 (in length 2.9 or 35%); lower jaw 13 (in length 3.0 or 33.8%); postorbital width of head 9.1 (in length 4.2 or 23.6%); interorbital width 4.4 (in postorbital width of head 2.07 or 14.2% of length); length longest fang 5 (in interorbital width .88 or 13%of length).

Illicium: From the anterior distal portion of the major, pigmented bulb arises a much smaller bulb, round and unpigmented. Both bulbs are enclosed in a translucent envelope which is distinctly compressed longitudinally, arising considerably below major bulb, and projecting well beyond it anteriorly, dorsally and posteriorly, although it is stretched tightly over the distal half of the minor bulb; it shows no trace of distal pigmentation. Behind the minor bulb the envelope gives rise to two minute flaps, facing



TEXT-FIG. 1. Melanocetus megalodontis, holotype. A. Dentition. Depressible teeth unshaded. B. Illicium.

anteriorly, side by side; the posterior part of the envelope shows several asymmetrically placed ribs or wrinkles not due to post mortem shrinkage.

Teeth: In each half of the upper jaw are 3 large fangs, the third longest, inserted near the inner margin of the jaw. External to these is a series of about 16 to 20 smaller teeth, including 4 or 5 which are moderately enlarged, the remainder being minute. In each half of the lower jaw are 4 or 5 fangs, the second of which is enormous, and 8 or 9 small teeth, most of them minute. Vomer with 4 teeth close together. Four pharyngeal teeth on each side.

Fins: Pectoral 19; dorsal 15; anal 14; caudal 10.

Food: Three scarlet-eyed euphausiids, packed together, each 25 mm. long. All have been identified by Dr. H. J. Hansen as male Euphausia eximia.

Behavior: The fish lived for two hours after which we preserved it. In the dark room we caught a fairly strong orange gleam, given forth three times, but could not be sure the illicium was the source. It swam actively but slowly about, with alternate movements of the pectorals. When the caudal moved from side to side it wagged the whole fish. When the gill opening closed the lower part remained immovable, the upper portion pressing down obliquely, leaving much of the lower half wide open. The position in life was exactly like Brauer's old illustration of *Melanocetus krechi* (1906, Taf. 15, fig. 3).

DISCUSSION.

This proposed new species differs from all the others as follows: in the character of the illicium; in the great length and robustness of the fangs, the length of the largest being greater than the interorbital width; and in the shortness of the lower jaw, which in spite of the small size of the specimen is only about a third of the total length. The fish clearly belongs in the long-fanged group in the key given by Regan & Trewavas (1932, p. 49), and, among these, is perhaps most closely related to M. murrayi on the one hand and to M. ferox on the other.

Melanocetus niger Regan, 1925.

References: Melanocetus niger Regan, 1925, p. 565; Regan, 1926, p. 33, plate VIII, fig. 1; Regan & Trewavas, 1932, p. 53, fig. 76B.

Range: Eastern Pacific: Gulf of Panama and 500 miles to the west near Cocos Island. The present specimens are the first to be taken outside the Gulf.



TEXT-FIG. 2. Xenoceratias nudus, holotype. A. lateral view. B. Head, lateral view. C. Head, dorsal view. Dotted lines indicate externally invisible lamellae.

Specimens Taken by the Eastern Pacific Expeditions: Four specimens, from 500 to 833 fathoms, off Gulf of Panama and Cocos Island, one adult, length 113 (85+28) mm.; three transitional adolescents 72 (52+20) mm., 23 (14+9) mm. and 20 (13+7) mm.

Color in Life: 72 mm. fish: black, fins colorless except for pale pigment on the caudal; illicium stem dark brown, the luminous bulb black on the proximal three-fourths, translucent white at the tip, enclosing a small, opaque black organ.

Counts and Measurements: The 113 mm. specimen is the largest recorded, and shows the following details of counts and size: Dorsal fin 14, anal 4, pectoral 20; length 113 (85+28) mm., maxillary 40, mandible 42, mouth width 61, illicium 30, postorbital 23, interorbital 15, longest tooth 4.

Ovaries: Typical of the ceratiid. 113 mm. specimen: ovaries dorsal, one considerably behind the other, much foliated, enclosed in lightly pigmented membrane; length 10 mm., anterior breadth 6 mm., tapering posteriorly, little compressed; eggs minute, closely packed, all about the same size; ovaries too small to be considered in breeding condition, though much better developed than in 72 mm. specimen.

72 mm. specimen: Ovaries parallel, posterior, between bladder and end of intestine, as in Regan & Trewavas, 1932, p. 15, fig. 22, of a young specimen. In the present example, however, they are relatively larger, as long as bladder; length 3.5 mm., maximum breadth 1 mm.

Food: The 23 mm. specimen contained two entire copepods.

Study Material: Cat. No. 5889 (KOH No. 18)²: Arcturus Oceanographic Expedition; Station 74 PT2; 60 miles south of Cocos Island (4° 50' N. Lat., 87° W. Long.); 600 fathoms; May 25, 1925; length 20 (13+7) mm.

Cat. No. 6332: Arcturus Oceanographic Expedition; Station 74 T76; same locality; 500 fathoms; June 3, 1925; length 23 (14+9) mm.

Cat. No. 6414 (KOH 34): Arcturus Oceanographic Expedition: Station 74 OT3; same locality; 833 fathoms; May 29, 1925; length 72 (52+20) mm.

Cat. No. 28,642: Eastern Pacific Zaca Expedition; Station 228 T1: 52 miles SE \times E of Cape Mala, Panama (7° N. Lat., 79° 16' W. Long.); 500 fathoms; March 25, 1938; length 113 (85+28) mm.

Xenoceratias nudus sp. nov.

(Text-fig. 2).

TYPE.

(The unique specimen).

Department of Tropical Research No. 28,402; Eastern Pacific Zaca Expedition of the New York Zoological Society; Sta. 210T-8; Feb. 27, 1938; 500 fathoms; 20 miles south of Cape Blanco, Costa Rica (9° 12' N. Lat., 85° 10' W. Long.); total length 31.4 (21.4+10) mm., a transitional adolescent with moderately developed testicles (measuring about 3.5×2.4 mm. in length and breadth).

DESCRIPTION.

With the characteristics of the genus. Skin unpigmented, naked, slightly inflated. Depth of body in standard length 2.7. Snout moderately long, obliquely descending. Rostrum sharply defined, with a median series of rudimentary spinules, consisting of two minute ones anteriorly and, behind these, several subdermal ones clearly visible by substage lighting, indicated externally only by the pushing of the skin into minute serrations. Tip of rostrum with 10 curved denticles in an irregularly double series; denticles in front of lower jaw in the three series characteristic of the genus, although the posterior members of the median group are not separated from those of the lateral groups; the counts are as follows: left lateral 5, median 9 (three anterior followed by three pairs behind one another with several posterior individuals still subdermal), right lateral 4. Median prominence opposed to rostral denticles; lateral prominences erect, outside anterior ends of premaxillaries; premaxillary about reaching vertical from anterior of eve. Anterior nostril small, round on a separately inflated prominence; posterior nostril well separated from it and from eye; irregularly oval, its vertical diameter about twice that of anterior nostril and about equal to that of eye; 1% olfactory lamellae, the most dorsal one being very small, only the upper ones exposed. Testicles only partially developed, about 7 mm. in length. Dorsal 14 or 15; anal 4; pectoral about 18; caudal 9.

Affinities: Close to X. longirostris Regan & Trewavas, 1932, the only other member of the genus recorded from the Pacific. The proposed new species differs chiefly in the lack of body spinules and in the rudimentary condition of those on top of the rostrum. There are minor differences in the relative size of the nostrils, in the larger number both of lamellae, and of the denticles in front of lower jaw. All of these may prove to be merely growth characters and individual variation, but in view of the number of species of Melanocetus recorded from the Eastern Pacific area, it seems desirable to record the species as distinct.

FAMILY HIMANTOLOPHIDAE.

Himantolophus azuriucens sp. nov.

(Plate I, Figs. 1, 2; Text-figs. 3, 4).

TYPE.

(The unique specimen).

Department of Tropical Research No. 28,641; Eastern Pacific Zaca Expedition; Station 228, T-1 (7° N. Lat., 79° 16' W. Long.); 52 miles SE \times E of Cape Mala, Panama; 500 fathoms; March 25, 1938; total length 123 (98+25) mm.

²Owing to catalogue confusion between regular and KOH numbers, this specimen was erroneously recorded as No. 6552 from Station 113, T35, 600 fathoms, in Hudson Gorge, Atlantic Ocean (*Zoologica*, VIII, No. 1, 1929, p. 18).



TEXT-FIG. 3. *Himantolophus azurlucens*, holotype. A, Freshly caught specimen, lateral view. B, Preserved specimen, showing distortion.

DESCRIPTION.

With the characteristics of the genus.

Color.: Jet black, paling to smoky gray in groove under illicium, and down the back to dorsal fin; also on flattened belly from chin to anal fin. All fin rays black, webs transparent. See additional color under *Lumin*escence.

Luminescence: Body with conspicuous, sharp, sparsely scattered spines. Three of these, two on the left and one on the right upper posterior back, have luminous turquoise blue bases. A patch, not a spine, of the same color on upper, and another on lower base of peduncle; five luminous-based spines in a loose group on belly in front of anal fin; a triangular patch at anterior base of anal fin; others on the upper and lower caudal rays and on the anterior anal ray. In daylight all are brilliant turquoise blue, and in





the darkroom we got pale blue luminescence from several of the spine bases and from two of the patches. In the dead preserved fish all trace of blue color is lost, the areas being distinguishable only by a slightly paler color of the tissue. Much of the illicium and its tentacles and many of the snout and chin papillae were distinguishable as pale grayish-white in the dark, and several times before the fish expired we detected flashes of yellow light, possibly from the facial papillae and illicium stem, but strongly from the swollen distal end of the illicium club, at the base of the tentacles.

Cephalic Papillae: Upper lips, snout and

TEXT-FIG. 4. *Himantolophus azurlucens*, holotype. A. Preserved specimen, anterior view. B. Illicium.

base of illicium covered with a mass of rounded, tumid papillae of varying size, increasing in size as they approach the mouth. A few of these on the upper lip are pale gray. A second compact, swollen patch on lower lip very conspicuous, pinkish or fleshy white in daylight. Surrounding the periphery is a narrow zone of smaller papillae of a neutral gray.

Illicium: The large, complex illicium lies normally on and partly in the groove scoooped out of the back. At least six or eight times, while the fish was swimming in a dish of iced water, the illicium was brought forward so far that the terminal tentacle overhung the mouth, well in advance of it. (We say tentacle because originally there were two, but when the fish was taken out of the net it had lost three-fourths of one tentacle. This was later found in the glass jar at the end of the net).

The main illicium stem is thick, black for about a fifth of its length, the distal fivesixths studded with round-based, low but sharp spines, all pale gray in color. The distal end of the stem is enlarged, club-like, on which the spines flatten out and merge into a solid pale gray. Yet the minute points are distinct even to the flat end and rim in the monocolored area.

The extreme tip of the stem is flattened and silvery white and it was this area which gave forth the strongest flashes of yellow light in the darkroom. From the flattened portion there arise, side by side, two silvery tentacles, rather thick at the base and tapering slightly to a slender, but blunt, fingerlike tip. The tentacle which was torn away is shorter than its fellow, and bears two stemmed and lobed bodies half-way to the tip. These are absent from the other. Illicium base to bulb tip 31.5, longer illicium tentacle 31, illicium total length 62.5 mm.

Spinous Bony Plates: On each side of the body, from gill arches to base of caudal fin, there are 26 or 27 low sharp spines, each arising from a small, subdermal p'ate. They are not arranged in perfect symmetry on the two sides, although total counts and general positions correspond closely. Their location on each side is as follows: on skin covering gill arches, 5 and 6; anterior base of pectoral, 5 and 7; each side of midline of abdomen, 4 and 6; anterior base of anal, 1; lower part of side, 2 and 3; upper part of side, 7.

Teeth: Small, in series, all depressible, except smallest in outer rows particularly in premaxil'ary. Upper jaw teeth in two irregular rows, outer series with very small teeth, close-set, varying in size, extending entire length of mouth; inner row composed of larger teeth chiefly in anterior part. widely spaced and smaller posterior'y. Mandible with teeth larger and more numerous than in premaxillary, set in four or five rows, runring entire length of jaw, in a somewhat quincunxial arrangement, increasing in size from outer to inner series.

Fin Counts: Dorsal 5 (last four bifid), anal 4 (last three bifid), pectoral 17, caudal 9 (seven bifid).

Ovaries: Posterior. parallel, small (9 by 6 mm.), compressed. Eggs minute. all same size. Judged by the ovaries, the fish would be classed as a transitional adolescent.

Food: 1 Sternoptyx, length 19 mm.; 4 Cyclothone, length 15-30 mm.; 1 Melamphaeslike fish, length 25 mm.; 1 adolescent myctophid. length 10 mm.; 1 adolescent sudid, length 22 mm.; 2 euphausids (possibly shrimps), 45 mm.; 3 small euphausids, 15-20 mm.; 2 gammarid amphipods (possibly food of above food), 6 and 7 mm.; assorted small copepods (probably food of food); squid beak.

Behavior: This Blue-lighted Anglerfish was brought up at 2:30 p. m. and was very much alive, swimming around its large dish, keeping upright and twice biting the finger of the senior author as he turned it over. As we have said, the entire illicium was occasionally thrown forward, until the stem almost touched the snout, the slender remaining tentacle waving back and forth as the stem moved. It swam almost entirely by movements of the caudal fin but turned with the help of the pectorals. It lived until 5 o'clock in ice water, then expired slowly, and only lost its shape when put into preservative. The stretched mouth and the greatly distended gill arches gave it a wholly abnormal contour.

Discussion: This new member, the fourth of the genus *Himantolophus*, is the most specialized as regards illicium, dermal tubercularity, armature and luminescence. The three most characteristic features are the spiny armed illicium, the non-spinous cephalic papillae of snout and chin, and the patches of brilliant turquoise blue luminescence on body and fins.

FAMILY ONEIRODIDAE.

Chaenophryne parviconus

Regan & Trewavas, 1932.

References and Synonymy: Chaenophryne parviconus Regan & Trewavas, 1932, p. 87, fig. 138; Chaenophryne columnifera l. c., p. 88, fig. 140; Chaenophryne melanorhabdus l. c., p. 98, fig. 143.

Range: Eastern Pacific, within an isosceles triangle bounded by the Gulf of Panama, Cocos and Galápagos Islands, and Cape Corrientes, Colombia.

Specimens Taken by the Eastern Pacific Expeditions: Six specimens, from 400 to 700 fathoms, off Gulf of Panama, Cocos and Galápagos Islands, total lengths 17.3 to 25 mm., young transitional adolescents.

Color and Luminescence: These small fish were jet black in life. No. 6226 in the dark room gave forth two rather long drawn out flashes of pale yellow light from the balllike organ at the tip of the illicium, the second flash being the stronger. In daylight the rounded or, in other specimens, slightly elongated structure showed a strong iridescence in striking contrast with the jet black skin.

Development and Discussion: The six specimens of the present collection indicate that at least three of the species of Chaenophryne described as new by Regan & Trewavas, 1932, represent stages in development and should be synonymized. These three species are parviconus, columnifera and melanorhabdus, all from the Gulf of Panama. C. parviconus and columnifera are described from 9 and 3 specimens respectively, of similar size, 16 to 21 mm. in total length, while melanorhabdus is known from the unique holotype, 55 mm. long. Except for 6, not 7, rays in the dorsal of melanorhabdus, and 15. not 16 to 17. rays in the pectoral. all of the described differences separating the three species are in the illicium: In our series, 3 of the 5 specimens have 6 dorsal rays, the others 7. Pectoral counts are especially difficult in this group, and ours are uncertain, but appear to range from 14 to 17.

Two of the present six specimens, total lengths 17.3 and 24 mm., agree perfectly

with the description and illustration of C. parviconus, in which the illicium shows relatively simple development. The third and fourth, 18 and 19 mm. long, have the conical distal papilla of the bulb slightly longer than in parviconus, but not as long as in columnifera. The fifth and sixth specimens, 18.6 and 21 mm. long, have the distal papilla relatively as long as the 55 mm.-long melanorhabdus, but lack the anterior branched filaments, in this respect resembling colum*nifera*. However, the filaments appear to be represented subdermally by a pair of rudimentary, tiny, curved, dark tentacles at the base of the distal papilla; it may be that the "basal pair of luminous patches" in Regan & Trewavas's description of columnifera, present also in our specimens, are also rudiments of tentacles. In any event, there now appears to remain no valid reason for maintaining the three species, and *parviconus*, by pagination priority, is accepted as the specific name.

The typically parviconus-like specimens appear more juvenile than the columniferamelanorhabdus-like pair in development of teeth and in that of the base of the illicium, in addition to the simple character of the bulb already mentioned. In each of these four the basal bone is very short, and the tip of the bulb, when laid back, reaches no further than the vertical from the posterior edge of the eye. In the *melanorhabdus*-like 21 mm. specimen (taken in the same net with a *parviconus*-like stage) the basal bone is still short, but the entire illicium bulb lies beyond the level of the eye; in the 18.5 mm. example, the basal bone is as long as the illicium stem, the illicium, including bulb, measuring about one-fifth the length of the fish (as compared with two-sevenths in the 55 mm. type of *melanorhabdus*). The length of the fringes on the wings of the posterior bulb appendages vary regardless of age.

In deep-sea pediculates, as in other fish groups, shrinking occurs to variable degrees during metamorphosis (that is, in adolescence and early transitional adolescence). This is clearly evident in this series, where the 25 mm. fish is one of the youngest, judged by tooth and illicium develop-ment, and, of the two best developed examples, the 18.6 mm. specimen is younger than that of 21 mm. The latter shows youth also in its relatively greater depth, because of the juvenile fatty tissue. The stomachs (empty) of these two oldest samples are entirely unpigmented and the ovaries are minute. There is no doubt but that all the specimens are extremely immature, in spite of the fact that in life the exterior black pigment was fully developed.

Study Material: Cat. No. 5209; Arcturus Oceanographic Expedition; Station 33, PT- 1, 70 miles N.E. of Tower Island, Galápagos $(0^{\circ} 40' \text{ N. Lat.}, 88^{\circ} 51' \text{ W. Long.})$; 700 fathoms; April 3, 1925; total length 19 (15+4) mm.

Cat. No. 5210; same station, net, locality, depth and date; total length 17.3 (13.6+3.7) mm.

Cat. No. 6226; Col. Pl. 2104; Arcturus Oceanographic Expedition. Station 84, T-8; one mile N. of Narborough, Galápagos (0° 17' S. Lat., 91° 34' W. Long.); 400 fathoms; June 9, 1925; total length 25 (19.3+5.7) mm.

Cat. No. 6645; Col. Pl. 2069; Arcturus Oceanographic Expedition; 74, T-78; 60 miles S. of Cocos Island (4° 50' N. Lat., 87° W. Long.); 700 fathoms; June 3, 1925; total length 18.3 (14+4.3) mm.

Cat. No. 28,766; Eastern Pacific Zaca Expedition; Station 233, T-1; 55 miles SSW Cape Corrientes, Colombia (4° 45' N. Lat., 78° 02' W. Long.); 500 fathoms; April 3, 1938; total length 18 (14.4+3.6) mm.

Cat. No. 28,767; same station, net, locality, depth and date; total length 21 (16.3+ 4.7) mm.

Dolopichthys luetkeni Regan, 1925.

References and Synonymy: Dolopichthys luetkeni Regan, 1925, p. 562; 1926, p. 27, pl. IV, fig. 2; Regan and Trewavas, 1932, p. 76, fig. 116; Dolopichthys heteracanthus Regan, 1925, p. 562; 1926, p. 28, pl. V, fig. 4; Regan & Trewavas, 1932, p. 77, fig. 117.

Range: Eastern Pacific; off Costa Rica from 9° 12' N. Lat. south, Gulf of Panama and off Cocos Island.

Color: Jet black. The outer sheath of illicium is colorless; terminal, rounded bulb encloses a lemon yellow body, topped by a cap and a slender, finger-like tentacle, all of glistening silver tissue. Behind these, a second candle- or finger-like tentacle arises, with an orange, flame-like appendage, topped by a short, very slender filament.

Discussion: We agree with Parr (1927, p. 15) in considering D. heteracanthus to be the immature form of D. luetkeni. Although in our series, composed entirely of small examples, the posterior appendage is smaller than the anterior, as in heteracanthus, there is considerable variation in its length and in other details of the bulb, the amount of fringing on the anterior flaps varying, as well as the position and subdivisions of the membraneous appendages behind it. In our specimens these membranes are set at varying angles to the anterior flaps, but always are more nearly one above the other as in *luetkeni*, rather than one behind the other as in heteracanthus. All of the present specimens are clearly immature, with feeble teeth in varying stages of development, large articular spines, and basal bone much shorter than illicium.

Study Material: Cat. No. 5944; Col. Pl. 2103; Arcturus Oceanographic Expedition; Station 74, PT3; 60 miles south of Cocos (4° 50' N. Lat., 87° W. Long.); 620 fathoms; May 27, 1925; total length 25.5 (18.5+7) mm.

Cat. No. 6011; Arcturus Oceanographic Expedition; Station 74, OT4; 60 miles south of Cocos (4° 50' N. Lat., 87° W. Long.); 625 fathoms; May 30, 1925; total length 29 (22+7) mm.

Cat. No. 28,247; Col. Pl. Z185, fig. 1; Eastern Pacific Zaca Expedition; Station 210, T-1; 20 miles south of Cape Blanco, Costa Rica (9° 12' N. Lat., 85° 05' W. Long.); 300 fathoms; Feb. 7, 1938; total length 20.3 (14.3+6) mm.

Cat. No. 28,768; Eastern Pacific Zaca Expedition; Station 219, T-1; 25 miles $W \times N$ of Pt. Burica, Costa Rica (8° 08' N. Lat., 83° 17' W. Long.); 300 fathoms; March 10, 1938; 3 specimens, total length 18 (13.6+(4.4); 19.3 (12.9+6.4) and 21 (14.7+6.3) mm.

Dolopichthys implumis

Regan & Trewavas, 1932. (Text-fig. 5).

Reference: Dolopichthys implumis Regan & Trewavas, 1932, p. 78, fig. 122.

Range: Eastern Pacific: from Gulf of Panama north to 9° 15' N. Lat., off Costa Rica, and southwest to the Galápagos.

Specimens Taken by the Eastern Pacific *Expeditions*: Two specimens, both from 500 fathoms, off Costa Rica and Galápagos respectively; total lengths 18.7 and 20.2 mm.

Color: Jet black; bulb and short stem of illicium blue black, tentacles silvery, medium comb translucent white.

Discussion: Three small specimens have heretofore been recorded, all from the Gulf of Panama, by Regan & Trewavas. Although the top of the posterior appendage in our specimens is oblique, not horizontal as in their drawings, there is no other appreciable difference; the shape and height of our papillae vary even in our two specimens. There seems no reason why Regan & Tre-wavas's entire subgenus *Microlopichthys*, known solely from small specimens, will not prove to be composed merely of young forms of another group-very likely of the subgenus Dolopichthys. The vital factor in question is how fast and when the basal bone of the illicium is exserted and lengthens. We think this must be a suddenly accelerated character, and at the same time when it hurries up its growth, the bulb ornaments lose their simplicity. We can compare this with the sudden growth change in leptocephalids and some melanostomiatids, where individuals of very different appearance occur of the same length, and others show a similar appearance but unequal lengths, during metamorphosis.



A В TEXT-FIG. 5. Dolopichthys implumis Regan & Trewavas. End of Illicium. A, Specimen



Study Material: Cat. No. 6286a, Col. Pl. 2099; Arcturus Oceanographic Expedition; Station 84, T-14; one mile north of Narborough, Galápagos (0° 17' S. Lat., 91° 34' W. Long.); 500 fathoms; June 9, 1925; total length 18.7 (14.7+4) mm.

Cat. No. 28,401; Eastern Pacific Zaca Expedition; Station 210, T-8; 20 miles south of Cape Blanco, Costa Rica (9° 12' N. Lat., 85° 10' W. Long.): 500 fathoms; Feb. 27, 1938; total length 20.2 (14.5+5.7) mm.

Dolopichthys pullatus

Regan & Trewavas, 1932. (Text-fig. 6).

Reference: Dolopichthys pullatus Regan & Trewavas, 1932, p. 79. text-fig. 123, pl. III, fig. 1.

Range: Unique specimen previously known taken in the Mollucas.

Specimen Taken by the Eastern Pacific Expedition: One specimen; Cat. No. 28,769; Station 233 T-1; Eastern Pacific Zaca Expedition; 55 miles SSW of Care Corrientes, Colombia (4° 45' N. Lat., 78° 02' W. Long.); 500 fathoms; April 3, 1938; total length 23.6 (19.3+4.3) mm.; transitional adolescent.

Measurements: Illicium: basal bone 1.6 mm., stem 3.9; stem and bulb (without flange) 5.6; bulb alone 1.7; distal flange 1; mandible 8.

Teeth: Upper jaw with about 35; lower jaw, 44 or 45; all slender, close-set, in a single series, in successive groups of 3 or 4; the members of each group decrease progressively in size posteriorly; groups obsolete in posterior part of premaxillary, where teeth are short and irregularly spaced; 3 teeth on each side of vomer.

Fins: Pectoral 20 or 21; dorsal 6; anal 4. *Remarks*: This specimen is referred with hesitation to *pullatus*, known from a single East Indian specimen twice its length; it agrees almost equally well with D. mucronatus Regan & Trewavas, 1932, and one or two others of the same subgenus, and is the first of its close relatives to be recorded from the Eastern Pacific. However, it agrees almost perfectly with pullatus, differing noticeably from the description and figures only as follows: the kidney-shaped bulb is almost vertical instead of horizontal; the exserted part of basal bone is shorter and the lower jaw is slightly longer (both characters to be expected in a younger fish) and there are a few more teeth in the lower jaw (about 45 instead of 40) and 3 instead of 2 teeth on each side of the vomer. Most of the posterior appendage, indicated by dotted lines in our Text-figure, was broken off and lost shortly after capture; however it was measured and a sketch made when the specimen was freshly caught.

Dolopichthys aliector Garman, 1899.

(Text-fig. 7).

References: Garman, 1899, p. 81, plates XIII-XVI; Regan, 1926, p. 28 (part?); Regan & Trewavas, 1932, p. 80.

Range: Eastern Pacific: Gulf of Panama and off Galápagos Islands.

Specimen Taken on Eastern Pacific Expeditions: One specimen; Cat. No. 6394; Arcturus Oceanographic Expedition; Station 87 T-3; 21 miles NW of Narborough, Galápagos 0° 00', 91° 53' W. Long.); 450 fathoms; June 13, 1925; total length 25 (19+7) mm.; transitional adolescent.

Discussion: Regan, after accrediting nine small specimens in 1926 to D. allector, redistributed 7 of them to other species in 1932, and makes no mention of the remaining 2 fish. Hence Garman's type of 72 mm. from the Gulf of Panama is left as the only certain representative before the present specimen. From the original type our fish differs in possessing a single tooth on one side of the vomer, and in the greater length of the illicium stem as compared with the basal bone. Instead of being equal in length, this stem is two and a half times as long (basal bone 2.8, illicium stem 5.3, bulb and tentacle 1.4 mm.). We have elsewhere discussed the probable unimportance of this

acceleration of illicium stem growth. The bulb itself is somewhat more like that of danae from the north than that of allector. The posterior tentacle arises from a rounded appendage of the bulb, this ap-

TEXT-FIG. 6. Dolopichthys pullatus Regan & Trewavas. Illicium. Broken terminal flange indicated by dotted lines.



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TEXT-FIG. 7. Dolopichthys allector Garman. End of illicium. Broken filaments indicated by dotted lines.

pendage having, in addition, a distal papilla. In Garman's type the tentacle appears to rise directly. Our tentacle has at least two marginal filaments, the basal appearing bifid.

Dolopichthys atratus

Regan & Trewavas, 1932.

References: Regan & Trewavas, 1932, p. 81, fig. 129.

Range: Eastern Pacific; Gulf of Panama and off Costa Rica and Cocos Island.

Specimens Taken on Eastern Pacific Expeditions: Two specimens, from 500 fathoms, off Costa Rica and Cocos Island, total lengths 25.7 and 41.7 mm.

Color: Jet black to the tip of all the fins. Basal bone dark brown, illicium stem pale brown, bulb blue and tentacle colorless.

Illicium: There is considerable variation in length and distribution of filaments on the distal tentacle of the illicium in the two fish. In the 41.7 mm. specimen the basal bone is 2.4, illicium stem and bulb 7.1, and tentacle 4.3 mm. In the smaller fish of 25.7 mm., the basal bone is practically sessile or subdermal, the stem and bulb 4.7 and the tentacle 3.5 mm. The teeth are more than twice as numerous in the lower jaw in the larger specimen.

Study Material: Cat. No. 6640, Color Plate 2070; Arcturus Oceanographic Expedition; Station 74, T-4; 60 miles south of Cocos (4° 50' N. Lat. 87° W. Long); 500 fathoms; May 25, 1925; total length 41.7 (32.9+8.8) mm.

Cat. No. 28,274; Eastern Pacific Zaca Expedition; Station 210 T-6; 20 miles south of Cape Blanco, Costa Rica (9° 12' N. Lat., 85° 05' W. Long.); 500 fathoms; Feb. 7, 1938; total length 25.7 (20+5.7) mm.

Genus Trematorhynchus

Regan & Trewavas, 1932.

Six specimens in the present collection are male oneirodids. All possess the characters of the genus *Trematorhynchus*, as set up by Regan & Trewavas to receive the few known males in this diverse family of many genera and species. As in those previously recorded, all of our specimens have the skin naked, the snout short and somewhat decurved, the nostrils not raised, the anterior nostril opening forward near end of snout, teeth in both jaws lacking, and denticles present above and below, including an outer series on the chin.

They all fit well enough into the species framework of T. *leucorhinus* Regan & Trewavas (1925, p. 566; 1930, p. 44, fig. 25b; 1932, p. 91), having large nostrils of which the anterior are almost contiguous and the posterior set close to the eyes, while the nasal area is more or less pale. This species, described from the Atlantic and Indian Oceans and the Gulf of Panama, is also the only one which has been hitherto recorded from the Pacific. However, we agree with Parr (1934, p. 41) that sharper specific differences must be sought in the material upon which leucorhinus is based, and in the absence of a designated holotype, we are proposing five new species. Although it is likely that some of our material will prove to agree with some of Regan & Trewavas' Pacific examples, synonymy is impossible without comparison of specimens and, preferably, a large amount of new material.

In addition to the usual diagnostic characters of fin ray counts, curvature of snout, nostril shape, size and position, eye size and denticle number, arrangement and projection, the number of olfactory lamellae appears to be of value in this group. This character has already been used by Regan & Trewavas (1932) in the specific descriptions of Xenoceratias. Additional material will doubtless show that the shape of the individual lamellae also has importance. Eye diameter in length of dentary is sometimes a useful character. The amount of expansion of the dermal envelope will probably also prove to have a diagnostic value, although it is certainly also connected with development.

Judging by the rudimentary development of pigment and the small size of the testicles, none of the six specimens is adult; however, the diagnostic characters mentioned above are so well developed that descriptions of these fish, as advanced transitional adolescents, appear warranted.

As Parr has indicated, there seems to be little use in erecting new genera for these males in our present state of ignorance, even though some of the differences obviously transcend generic boundaries.

The large nostrils at once distinguish all five of the proposed new species, as well as *leucorhinus*, from the other *Trematorhynchus* thus far described (*exiguus* and *obliquidens*, both of Regan & Trewavas, 1932, and *phyllodon* Parr, 1934, all from the Atlantic). The following key is given only to clarify the major distinctions in the present material.

A. Lamellae 7; eye small (3.7 in

dentary) *paucilamellatus* AA. Lamellae 11-15; eye large

- (2-2.2 in dentary)
 - B. Rostral denticles 3; outer skin inflated; D. 5.....adipatus

- BB. Rostral denticles 5-9; outer skin scarcely inflated; D. 6-7
 - C. P. 16-18; rostral denticles 5-6 D. Lamellae 15

multilamellatus

- DD. Lamellae 11-12 moderatus
- CC. P. about 27; rostral denticles9; lamellae 13...multiradiatus

Trematorhynchus adipatus sp. nov.

(Text-fig. 8).

TYPE.

(Unique specimen).

Department of Tropical Research No. 28,770; Eastern Pacific Zaca Expedition of the New York Zoological Society; Sta. 230 T-1, 71 miles W×S of Cape Corrientes, Colombia; length 15 (10+5) mm.; transitional adolescent with minute testicles.

DESCRIPTION.

Skin lightly pigmented, naked, consider-



TEXT-FIG. 8. Trematorhynchus adipatus, holotype. A. Lateral view. B. Head, lateral view. C. Head, front view. Dotted lines indicate externally invisible lamellae.

ably inflated. Head (to gill opening) contained slightly more than twice in standard length; snout obtuse, the rostral portion almost vertical, but rounded, not straight, in profile. A close-set series of 3 rostral denticles, all long and slender and strongly hooked. Opposite these, in front of the mandible is a series of 8 denticles, long and slightly curved, in an irregular cluster. Maxillary reaching vertical from about middle of eye; posterior process of dentary not quite reaching that from posterior margin of eye.

Eye contained about twice in distance from symphysis to end of posterior process of dentary. Anterior nostril oval, about 4/5 as long as diameter of eye; posterior nostril narrow, its length about 1.2 times diameter of eye. Septa separating nostrils from each other narrow, and from eves moderately broad. Twelve olfactory lamellae, of which 8 are visible in the posterior orifice in a lateral view.

Dorsal 5; anal 4; pectoral about 16; caudal 9.

DISCUSSION.

Distinguishing characteristics are the small number of rostral denticles (3) and the high degree of inflation. These may be merely signs of youth.

Trematorhynchus moderatus sp. nov.

(Text-fig. 9).

TYPE.

Holotype: Department of Tropical Research No. 28,771; Eastern Pacific Zaca Expedition of the New York Zoological Society; Sta. 230 T-1, 71 miles $W \times S$ of Cape Corrientes, Colombia; length 17 (11+ 6) mm.; transitional adolescent with testicles about 1.2 mm. long.

Paratype: Department of Tropical Research No. 28,772: same station and net as holotype; length 14.5 (10+4.5) mm.; transitional adolescent, slightly less well developed than above.

DESCRIPTION.

Skin scarcely pigmented, naked, inflation very slight. Head (to gill opening) contained slightly more than twice in standard length; snout obtuse. A series of 6 rostral denticles, all curved, the outer and inner pairs most. Denticles in front of mandible consisting of 1 or 2 inner, 4 marginal and 3 outer ones, all moderately curved, less so than rostral series. Maxillary almost or quite reaching vertical from middle of eye; dentary scarcely beyond that from its posterior margin.



TEXT-FIG. 9. Trematorhynchus moderatus, holotype. A. Lateral view. B. Head, lateral view. C. Head, front view. Dotted lines indicate externally invisible lamellae.

Eye contained about twice in distance from symphysis to end of posterior process of dentary. Anterior nostril narrow, 4/5 as long as diameter of eye; posterior nostril 1.25 times diameter of eye in holotype, but only 4/5 times diameter in the younger paratype, narrow in both specimens. Septa separating anterior and posterior nostrils narrow, between anterior nostrils broad, and between posterior nostrils and eyes broad. Twelve olfactory lamellae in ho'otype, 11 in paratype; 9 of these are visible in the posterior orifice in a lateral view in holotype, about 6 in paratype.

holotype, about 6 in paratype. Dorsal 6; anal 5; pectoral 17 or 18; caudal 9.

DISCUSSION.

In distinguishing this species, which has no striking characteristics, the combination of lamellae numbers, denticle arrangements and fin counts must be held of equal value.

Trematorhynchus multilamellatus sp. nov.

(Text-fig. 10).

TYPE.

(Unique specimen). Department of Tropical Research No. 6321; Arcturus Oceanographic Expedition of the New York Zoological Society; Sta. 86 T-10; 16 miles southwest of Narborough I., Galápagos; length *ca.* 15.5 (10.5+ca. 5) mm. transitional adolescent with minute testicles (about 1 mm. long).

DESCRIPTION.

Skin unpigmented, naked, slightly inflated. Head (to gill opening) contained slightly more than twice in standard length; rostrum practically vertical. A row of 5 denticles across tip of rostrum, the members of outer pair and median denticle most curved. Opposed to these in front of lower jaw is a row of 5 denticles, shorter and straight, and outside these a group of 5 minute spinules. Maxillary reaching verticle from middle of eye, and posterior process of dentary to slightly beyond eye's posterior margin.

Eye contained about 2.2 times in distance from symphysis to end of posterior process of dentary. Anterior nostril elongated, directed forward, its vertical axis slightly longer than diameter of eye; posterior broader, its vertical axis more than $1\frac{1}{2}$ times longer than eye. Septa, separating nostrils from each other and from eye, narrow. Fifteen olfactory lamellae, of which 12 to 13 are visible in the posterior orifice in a lateral view.



TEXT-FIG. 10. Trematorhynchus multilamellatus, holotype. **A.** Lateral view. **B.** Head, lateral view. **C.** Head, front view. Dotted lines indicate externally invisible lamellae.

Dorsal 7; anal 4; pectoral about 20; caudal ? (broken).

DISCUSSION.

The most noteworthy characteristic of this species is the great number of olfactory lamellae.

Trematorhynchus multiradiatus sp. nov.

(Text-fig. 11).

TYPE.

(Unique specimen).

Department of Tropical Research No. 28,773; Eastern Pacific Zaca Expedition of the New York Zoological Society; Sta. 225 T-1, 11 miles southwest of Jicaron Island, Panama; length 17.5 (11.5+6) mm.; transitional adolescent with minute testicles.

DESCRIPTION.

Skin scarcely pigmented, naked, slightly inflated. Head (to gill opening) contained twice in standard length; snout obtuse; a single row of 9 denticles across tip of rostrum, the outer pair strongly curved, the median denticle straight; the others asymmetrically straight and curved, in about equal numbers. Opposed to these, in front of lower jaw, is a row of about 8 denticles almost straight, and outside of these 3, wide-spaced, median, straight. Maxillary not reaching vertical from middle of eye; posterior process of dentary not quite reaching that from end of eye.

Eye contained about 2½ times in distance from symphysis to end of posterior process of dentary. Anterior nostril small, oval, only two-thirds diameter of eye; posterior long, curving, about half again as long as diameter of eye. Septa separating nostrils moderate. Thirteen olfactory lamellae, of which 10 are visible in the posterior orifice in a lateral view.

Dorsal 7; anal 4; pectoral about 27; caudal 8 (2 lower rays broken off short).

DISCUSSION.

The great number of rays in the pectoral, combined with their insertion on the upper and distal margins of the elongated lobe, make it likely that this male belongs to the genus *Ctenochirichthys* Regan & Trewavas, 1932, known from the Gulf of Panama.

Trematorhynchus paucilamellatus sp. nov.

(Text-fig. 12).

Type.

(Unique specimen).



TEXT-FIG. 11. Trematorhynchus multiradiatus, holotype. A. Lateral view. B. Head, lateral view. C. Head, front view. Dotted lines indicate externally invisible lamellae.

Department of Tropical Research No. 28,-250. Eastern Pacific Zaca Expedition of the New York Zoological Society; Sta. 210 T-3, 20 miles south of Cape B.anco, Costa Rica; length 17 (11+6) mm.; transitional adolescent with minute testicles (2 mm. long).

DESCRIPTION.

Skin lightly pigmented, naked, scarcely inflated. Head (to gill opening) more than half standard length; snout strongly perpendicular distally. A single row of 8 denticles across tip of rostrum, the outer and inner ones most curved, those next to the innermost almost straight. Above these is a minute, median denticle. Opposed to these, in front of lower jaw, a row of about 8 denticles, less curved, and below them two others, median, almost straight. Two tiny teeth, apparently on mandible itself, at symphysis. Maxillary reaching vertical from middle of eye; posterior process of dentary reaching slightly beyond vertical from posterior margin of eye.

Eye very small, contained 3.7 times in distance from symphysis to end of posterior process of dentary. Both nostrils large and vertically oval. Vertical diameter of anterior nostril about two-fifths longer than that of eye, of posterior about two-thirds. Anterior nostril directed straight forward. Septa separating nostrils from eyes and each other moderately narrow. Seven olfactory lamellae, all almost entirely exposed. Dorsal 7; anal 4; pectoral 17; caudal 9.

DISCUSSION.

The most conspicuous characteristics of this fish are the small number of nasal lamellae and the small size of the eye.

FAMILY GIGANTACTINIDAE.

Gigantactis perlatus sp. nov.

(Plate II, Fig. 3; Text-fig. 13).

TYPE.

(The unique specimen).

Department of Tropical Research No. 28,621; Eastern Pacific Zaca Expedition; Station 225 T-1 (7° 08' N. Lat., 81° 57' W. Long.); 11 mi. SW×W of Jicaron Is., Panama; 500 fathoms; March 20, 1938; total length 42 (34+8) mm.

DESCRIPTION.

With the characteristics of the genus.

Color: Jet black except for bulb of illicium which, in the fresh specimen, was completely semi-translucent white, except for a small, black, subdermal body less than halfway from base to tip of bulb. In the preserved fish, this body is practically invisible, the bulb now being olive brown, opaque except at the very base, which is still pale.



TEXT-FIG. 12. Trematorhynchus paucilamellatus, holotype. A. Lateral view. B, Head, lateral view. C, Head, front view. Dotted lines indicate externally invisible lamellae.



TEXT-FIG. 13. Gigantactis perlatus, holotype. End of illicium.

Proportions: Illicium longer than standard length, shorter than total (37 mm. to tip of bulb; bulb measures 3 mm.). Distance from last dorsal ray to caudal less than onefourth length of fish. Eyes appear to be practically non-functional.

Illicium: The bulb is similar to that of G. vanhoeffeni Brauer, 1902 (1906, pl. XV) from the Indian Ocean, being elongate, unpigmented, covered with pearl-like nodules, furnished with a number of tentacles and papillae, and having a round subdermal, presumably glandular body in the proximal half.

The pearl-like nodules are oval, round or irregularly quadrilateral, and commence close to the base, although they are not closely set before the distal half of bulb. They total around 150.

The filamentous ornaments consist of a pair of long tentacles arising from the tip of the stem; a pair of winglike, posterior basal flanges, each with several external papillae and an irregularly fringed edge; a pair of shorter posterior tentacles; a large unpaired posterior tubercle arising distal to the flanges and surmounted by a pore; two pairs of small elongate posterior papering distal tubercle covered irregularly with elongate papillae.

As reported under *Color*, the small, round black subdermal body so conspicuous in the proximal half of the bulb is now almost invisible. It appears to give rise to a tubercle connecting with the posterior pore mentioned in the preceding paragraph.

Teeth: Upper jaw: 2 on each side, well separated but close to symphysis, small, slender, curved. Roof of mouth (on upper pharyngeals?): 6 larger teeth on right side, 5 on left. Lower jaw: 10 on each side, much larger than in upper; 4 in a regular outer row, 6 in an irregular inner line.

Fin Counts: Dorsal 5, anal 5, pectoral 18, caudal 8.

Ovaries: Minute, less than 1 mm. in length.

Food: 1 copepod (length 6 mm.)

Discussion: The proposed new species is very close to Brauer's vanhoeffeni, known from two examples from the Indian Ocean. Our example is of the same size as the holotype of vanhoeffeni, and so is directly comparable. Body proportions are similar, as is the general character of the bulb. The differences are as follows:

(1). The proximal bulb tentacles are differently arranged and more complex, including the presence of the pair of winglike flanges. (2). The distal bulb tentacles are fewer, shorter and more irregular. (3). The pearl-like papillae studding the bulb are much more close-set and numerous. (4). There are 5, not 6, dorsal rays. (5). There are 18, not 16-17 pectoral rays.

FAMILY CERATIIDAE.

Cryptosparas normani

Regan & Trewavas, 1932.

(Text-fig. 14).

References and Synonymy: Cryptosparas couesii (non Gill), Norman, 1930, p. 354, fig. 44. Cryptosparas normani Regan & Trewavas, 1932, p. 98.

Range: South Atlantic, off South Africa; Eastern Pacific, off Galápagos.

Specimens Taken by the Eastern Pacific Expeditions: Two specimens, from 300 and 600 fathoms, off Galápagos Islands, total lengths 14.3 and 66 mm., transitional adolescents.

Discussion: Cryptosparas normani known only from the holotype taken off South Africa, is distinguished from couesii by Regan & Trewavas by the fact that the pore in front of the dorsal caruncles is at the end of a short tentacle, or elongate papilla, instead of arising directly from the dorsal skin, or from a slight prominence. This papilla is very distinct in our larger speci-



TEXT-FIG. 14. Cryptosparas normani Regan & Trewavas. A. End of illicium. B. Predorsal caruncles.

men, and of approximately the same size as that in the holotype. In our small dried specimen it is also clearly present. In all our Bermuda specimens, on the contrary, the pore is invariably of the typical, inconspicuous couesii form. In addition, the illicium bulbs of our Eastern Pacific specimens agree with the figure of normani in having the tentacle shorter than in couesii and a series of branches along each side, similar to those found in pennifer Regan & Trewavas, 1932, from the north of New Zealand. It is possible that these differences may prove to be merely individual variation, but until more material is available it seems best to maintain the several species.

In our Eastern Pacific specimens of normani there are more epidermal papillae than the six mentioned by Norman, and they are scattered asymmetrically.

they are scattered asymmetrically. Food and Ovaries: The stomach is empty; intestine crammed with soft black detritus, probably squid. Ovaries of larger specimen, 12 mm. long, moderately developed.

Study Material: Cat. No. 6284; Arcturus Oceanographic Expedition; Station 84 T-10; one mile north of Narborough, Galápagos (0° 17' S. Lat., 91° 34' W. Long.); 300 fathoms; June 9, 1925; length 66 (52+15) mm.

Cat. No. 6346; Arcturus Oceanographic Expedition; Station 86 T-9; 16 miles SW of Narborough (0° 42' N. Lat., 91° 47' W. Long.); 600 fathoms; June 12, 1925; length 14.3 (10.3+4) mm.

Mancalius uranoscopus (Murray, 1878).

References: Ceratius uranoscopus Murray, 1878, p. 67; Gunther, 1887, p. 54, pl. XI, fig. C. *Mancalius uranoscopus*, Norman, 1930, p. 355; Regan & Trewavas, 1932, p. 99; Parr, 1932, p. 12.

Range: Atlantic, Indian Ocean, Western and Central Pacific Ocean; present specimens first from Eastern Pacific.

Specimens Taken by Eastern Pacific Expeditions: Four specimens from 500 to 750 fathoms, off Cocos and Galápagos Islands, total lengths 24, 24, 24 and 140 mm. respectively. All four appear to be transitional adolescents, even No. 5991 which, although nearly six inches long, has undeveloped ovaries only 7.7 mm. in length.

Remarks: These are the first Eastern Pacific specimens taken, the closest being the type of *Myopsarus myops* Gilbert from Hawaii which, like our large one, lacks the illicium. This is the case with four out of the sixteen previously known individuals.

Our 140 mm. specimen No. 5991 appeared quite dead when brought up, and its struggles in the net had considerably abraded its skin. That life was not wholly extinct, however, was shown a few minutes after it was placed in ice water, when both stalked caruncles waved slowly back and forth alternately. There was no current in the aquarium nor motion of the ship so this was purely a muscular movement.

In Specimen No. 6214, at the very base of the main stem of the illicium, and posterior to where it arises from the skin of the back, is a well developed caruncle. This is quite as large as the third of the posterior group, but is almost hidden from lateral view as it arises from the bottom of the illicial groove. Instead of two, as seems more usual in this species, there are three caruncles in front of the soft dorsal fin, the third being median, anterior to the paired ones, and only about half their size.

In specimen No. 6286 the accessory caruncle near the illicium stem and the anterior of the posterior group are slightly less developed than in No. 6214, but still of good size and distinct to even a casual glance. The accessory caruncles and the narial spines are wholly absent from the large specimen No. 5991.

Specimen No. 6641 is identical in meas-urements with No. 6286. The post-illicial caruncle is better developed than in any of the others, but the anterior third dorsal one is absent, represented only by a pore, level with the surface of the skin. In the small individuals there is a short, curved keel along the basal half of the lowest caudal ray, and in No. 6214 this is developed into an incipient ray. If this were larger and slightly more distinct, we should have the ninth caudal ray which occurs normally in several related genera.

Mancalius uranoscopus typhlops Roule & Angel, 1933, 47 mm. in length, from near the Azores, has a stout, ray-like caruncle in front of the caruncles proper. This may be a young stage of *M. tentaculatus* Norman, 1932, 110 mm. long, or more probably, merely another variation in *uranoscopus*.

Study Material: Cat. No. 5991; Col. Pl. 2097; Arcturus Oceanographic Expedition; Station 74 OT-2; 60 miles south of Cocos (4° 50' N. Lat., 87° W. Long.) 750 fathoms; May 29, 1925; total length 140 (100 + 40)mm.

Cat. No. 6214; Col. Pl. 2094; Arcturus Oceanographic Expedition; Station 84 PT-1; one mile north of Narborough (0° 17' S. Lat., 91° 34' W. Long.); 500 fathoms; June 9, 1925; total length 24 (16.5 + 7.5)mm.

Cat. No. 6286; Col. Pl. 2076; Arcturus Oceanographic Expedition; Station 84 T-14; one mile north of Narborough (0° 17' S. Lat., 91° 34' W. Long.); 500 fathoms; June 9, 1925; total length 24 (17.5 + 6.5) mm.

Cat. No. 6641; Col. Pl. 6641; Arcturus Oceanographic Expedition; Station 74 T-78; 60 miles south of Cocos (4° 50' N. Lat., 87° W. Long.); 700 fathoms, June 3, 1925; total length 24 (17 + 7) mm.

FAMILY LINOPHRYNIDAE.

Acentrophryne ?longidens Regan, 1926.

(Text-fig. 15).

Reference: Regan, 1926, p. 3, pl. 1, fig. 2. Range: Gulf of Panama, and off western Costa Rica.

Specimen Taken by the Eastern Pacific Zaca Expedition: 1 specimen; Cat. No. 28,411; Sta. 210 T-10; 20 mi. south of Cape Blanco, Costa Rica (9° 11' N. Lat., 85°



TEXT-FIG. 15. Acentrophryne ?longidens Regan & Trewavas. Illicium.

08' 30" W. Long.); 500 fathoms; Feb. 27, 1938; length 60 (42 + 18) mm; an abnormal, immature female with rudimentary ovaries.

Color: Head and body sooty black; stem of illicium, outer sheath of bulb, and terminal appendage rising from posterior tip of sheath, all translucent and colorless; bulb blue-black.

Measurements and Proportions: Snout to gill opening 26 mm. i. e., slightly less than one-half total length. Illicium, total length 15 mm.; bulb 2.9 mm.; terminal appendage .96 mm.

Teeth: In each half of upper jaw, 5 or 6 small unequal teeth in a single series; in each mandibular ramus, 5 small, unequal outer teeth plus 1 to 3 long, inner fangs near symphysis. No teeth on vomer or pharyngeals.

Fins: D. 3, A. 3, P. 18, C. 8. Lateral Line System: The papillae on head and upper anterior side are similar to those of *Borophryne*, but the tags are all short, unpigmented, and less variable in length.

Remarks: Most of the body cavity of this specimen, including the inside of the expanded stomach, was filled with a tumor. Through the kindness of Dr. Ross Nigrelli, parasitologist of the New York Zoological Society, an account of the growth follows the present paper (Zoologica, Vol. 31, No. 12).

The fish agrees with Acentrophryne, previously known only from the 75 mm. type of A. longidens, from the Gulf of Panama,

in the following characters: preopercular spine lacking, although sphenotic and mandibular spines are well developed; teeth few; barbel lacking; iilicium consisting of a stem with an ovate bulb and short terminal appendage; pectoral 18.

It differs from the description and figure of the type as follows: dorsal and anal each numbering 3 not 4; teeth weak and relatively short; vomerine teeth lacking; illicium only about half as long as in Regan's illustration, with a smaller bulb but longer terminal appendage. These distinctions could be due either to disease or youth. The former explanation is preferable, since the type was only slightly longer than the present specimen. Obviously, certain identification is impossible without further, normal material.

Borophryne apogon Regan, 1925. (Plate II, Fig. 4).

References: Borophryne apogon Regan, 1925, p. 564; 1926, p. 23, pl. II, fig. 1; Regan & Trewavas, 1932, pp. 18, 106, textfigs. 7, 8.

Range: Tropical Eastern Pacific. The present series includes the first specimen taken outside the Gulf of Panama.

Specimens Taken by the Eastern Pacific Expeditions: Five specimens from 500 to 700 fathoms, taken from the vicinity of Cocos Island and of the Gulf of Panama. The series includes 2 large females, (total lengths 71 and 74.5 mm.), each with a male attached (18.3 and 17.4 mm. respectively), and 1 transitional adolescent female, (37 mm.).

Remarks on Females: Color: All three females, including a living large one with attached male, were jet black, the illicium filaments translucent milky white, and the heart of the bulb bluish-purple.

Luminescence: Female No. 28,707a came up alive and swam about strongly. In the darkroom there were occasional flashes of creamy white light, exact source undetermined, and now and then a purplish one from the bulb.

Teeth: Upper jaw: on each side, 5 or 6 long teeth with 8 to 10 small ones, of which some are close to the large teeth and are apparently of a replacement type. Lower jaw: on each side, 3 long teeth, of which the second is an enormous fang, and 8 to 11 small ones, some of a replacement nature. In both jaws the large teeth are interior to the others, which form a very irregular outer row. There is a pair of teeth on the vomer, with 2 subsidiary teeth in one specimen, 1 in the other, and a group of strong upper pharyngeal teeth, 4 or 5 on each side.

Fins: D. 3, A. 3, P. 15. In each female, the tips of all three rays barely project

externally, the sheath of dark skin extending to the tip, and the first two bound in a common skin almost to their ends. *Development*: The 37 mm. transitional

Development: The 37 mm. transitional adolescent female differs from the two adults in having relatively longer sphenotic preopercular and mandibular spines, and somewhat fewer teeth in the jaws. The illicium is almost as well developed as in the adult.

Gonads: The two large females, although of similar size and appearance, and termed 'adults" for convenience, show decided differences in the development of the ovaries. In 28,707a the ovaries measure about 15 imes 9 mm.; the eggs are .38 mm. in diameter, and appear almost ripe. In 28,708a, the ovaries are only about two-thirds as large with the eggs only .10 mm. in diameter and obviously unripe. The attached males, though externally showing little difference, show similar development discrepancies internally, the physiologically younger male being attached to the corresponding female (see page 172). Incidentally it is the older female that has the longer tentacles on the illicium bulb.

Comparison with Type Description: These females differ from the description and figures of the type series, which are of comparable length, as follows: (1). The gill opening, even in the transitional adolescent, is well behind the middle of the length excluding the tail, though slightly in front of the middle of the total length. The type description, reads "gill opening about in the middle of the length," and the illustration shows it at the middle of the standard length. (2). There are subsidiary teeth on the vomer, instead of a single pair, and there are more jaw teeth, especially small ones, than are shown in the plate. (3). The illicium differs from the illustration in small details; the forked tip of the terminal tentacle is shorter than the stem giving rise to it, not longer; however, this is a variable character, not being identical in the two specimens at hand; in one, even the branches of the fork are of unequal length. Also the mass of filaments arising from the bulb are variable; in one case (No. 28,707a, with better developed gonads) they extend well beyond the forked branches when laid against the latter, while in the other they are considerably shorter than the branches; likewise, their number, arrangement, and degree of branching, although similar, are not identical. Unlike Regan's illustration, the filaments extend also on the sides of the bulb immediately underneath the terminal forked tentacles, in addition to those extending down, anteriorly and posteriorly, as shown in the plate. They are much more numerous and branch more complexly than in the necessarily diagrammatic illustration. (4). Dissection and one cleared example show that there are definitely only 3, not 4, rays in both dorsal and anal fins. (5). The pale lateral line organs are on the dark "tags" described by Regan & Trewavas (1932, p. 24). It is to be noted, however, that in our specimens the peduncles are unequal in length, varying from almost sessile to .75 mm. long, and the organs of various sizes do not occur in the same positions in the two specimens. Number and distribution of the organs are also quite variable.

Remarks On Attached Males: Each of the adult females has a male attached slightly to the left of her ventral midline, a little behind the middle of the fish, one at a distance of 15 mm. in front of the anus and genital opening, the other at 10 mm. Both males are tastened upsidedown, that is, the body trailing posteriorly with the ventral surface opposed to that of the female.

Each specimen is further along in the course of parasitism than the two described by Regan & Trewavas (1932, p. 18). Each is firmly attached by both jaws, instead of only the lower, so that attachment by a single jaw proves to be invalid as a distinction from *Linophryne*. There is free passage of water into the mouth between the two jaws. No denticles are visible externally and there is no trace of a lateral line, although the cephalic system is apparent. In one (28,708b) there is no external trace remaining of dorsal or anal fins, while in the other the extreme tips of 3 dorsal and 2 anal rays project. Unlike Regan & Trewavas' specimens, where the sphenotic spine does not appear on one side, they are present externally on both sides (although of unequal length) in 28,708b, and on neither side, being sheathed in skin, in 28,707b. Both males were jet black, with conspicuous white nasal areas, while one of the previously recorded males was unpigmented.

Parr (1934, p. 58) queried the validity of identifying as one species two such dissimilar males as those of Regan & Trewavas, on the basis of their being attached to similar females. The present two indicate that the differences, including degree of pigmentation, merely indicate difference in development stage, first, in ordinary growth progress, and second, in degree of parasitic degeneration. None of the freeswimming males probably referable to Borophryne (see page 176ff.) is pigmented, and it seems likely that attachment occurs well before adulthood. Our two attached males internally show decided differences in degree of development of the testicles and degeneration of the other organs, the

less advanced (No. 28,708b) being attached to the female with less well developed ovaries (see p. 171). In this male, the testicles measure about 3.5×1.34 mm. and are kidney shaped. The stomach measures 1.8 and 18 still conspicuous. In male No. 28,-707b the testicles are more than half again as large, are much better developed, and are foided over on themselves, instead of being of the simple kidney shape. In this specimen, the organs were only exposed, not dissected, but it could be seen that the stomach and liver are both considerably smaller than in 28,708b.

In both males the eyes are directed forward and down which, in the attached position, is forward and up, toward the body of the female. There are 8 or possibly 9 nasal lamellae, apparently degenerating, and all except about 3 are invisible through the nostril. Dorsal 3; anal 3; pectoral about 15, the rays free in 24,708b, but almost sheathed in thick webbing in 24,-707b. Caudal 8, the dorsal and ventral pairs completely skin-sheathed.

Male No. 28,708b, along with a small patch of the female abdominal skin to which he was attached, was cleared and stained by the potassium-hydroxide-alizarin method. All of the skeleton with the exception of the rostral denticles is strongly ossified. These denticles are scarcely stained and very soft, although deeply buried in the tissue of the female; they number 4, a fifth, between the outer and central denticles on the left side, being represented by a vestigial stump. The rostral bone itself is strong.y ossified. The entire predentary bone is deeply stained, buried in female tissue. The typical *Aceratias*-type, forwardly-directed median denticle is present plus 4 strong, erect denticles on each side. Both jaws are toothless. The remainder of the skeleton agrees very well with the figure and description of Aceratias indicus given by Regan & Trewavas, 1932, p. 48, fig. 70.

In female No. 28,707a there are traces of what may be the result of recent abortive attempts of other males to attach themselves. One is about 5 mm. behind the male's present position, and is in the form of an oval, raw, skinless area, with even margins and a longitudinal diameter of 2.2 mm. There are two similar areas near the dorsal fin on the opposite side.

Remarks on Free-swimming Males. It appears certain that some of the Aceratias described on p. 176ff. are actually young free-swimming males of Borophryne apogon. However, until attached males of Linophryne and Acentrophryne, as well as large series of free-swimming young, can be studied exhaustively, internally and externally, we think it would be premature to refer any of the specimens to particular genera. It appears more profitable to treat the entire series as a unit illustrating general principles of linophrynid male development.

Food: Both the large females had the stomachs greatly distended with food. No. 28,707a contained the much digested remains of a single fish which must have measured at least 60 mm. in length. No. 28,708a held 3 fish, each about 50 mm. long: a *Lampanyctus* freshly swallowed, most photophores and many scales remaining; another myctophid, partly digested; and a third fish almost wholly digested.

Behavior: No. 28,707a, one of the two females with attached males, was alive when it reached the surface, and in an aquarium swam strongly and easily, using the caudal for propulsion and the pectorals only for turning. Her eyes moved slightly as she turned. The illicium was usually extended well forward, but several times it was jerked back and forth, and once flattened into its groove. The jaws moved through a slight arc, but never closed on account of the length of the teeth. Under a hand lens slight muscular twitches could be detected on the part of the parasitic male attached to her ventral surface.

Study Material: Cat. No. 6642: Arcturus Oceanographic Expedition: Station 74 T-78; 60 miles south of Cocos (4° 50' N. Lat., 87° W. Long.); 700 fathoms; June 3, 1925; transitional adolescent female, total length 37 (25+12) mm.;

Cat. No. 28,707a, 28,707b; Eastern Pacific Zaca Expedition; Station 234 T-1; 24 mi. W \times S of Pinos Pt., Panama (7° 24' N. Lat., 78° 35' W. Long.); 500 fathoms; Abril 4, 1938; female with parasitic male attached, total lengths 74.5 (51.5+23) and 17.4 (10.5+6.9) mm., respectively.

Cat. No. 28,708a, 28,708b; in same net as preceding; female with parasitic male attached, total lengths 71 (50+21) and 18.3 (10.8+7.5) mm., respectively.

Linophryne arcturi (Beebe, 1926).

(Text-fig. 16).

References: Diabolidium arcturi, Beebe, 1926, p. 80., fig. Linophryne arcturi, Regan & Trewavas, 1932, p. 107.

Range: Tropical Eastern Pacific.

Holotype, the Unique Specimen: Cat. No. 6333; Arcturus Oceanographic Expedition; Sta. 74 T-70; 60 miles south of Cocos Island, Costa Rica (4° 50' N. Lat.. 87° W. Long.); 500 fathoms; June 2, 1925; length 38.6 (28.6 + 10) mm.; transitional adolescent female with ovaries little developed.

Color in Life: Brownish-black; illicium with basal bone, basal half of stem, upper

part of bulb and stem portion of distal appendage dark brown; distal portion of stem, outer sheath and basal part of bulb, and distal filament all translucent white; all except tip of barbel dark brown; distal 5 mm. translucent white.

Luminescence: The white base of the candle-like organ showed distinct luminescence in the dark room during the first three minutes after capture. In addition, all the larger fangs were dimly outlined with luminescence, apparently resulting from a mucous coating.

Measurements and Proportions: Length 38.6 (28.6+10) mm.; snout to gill-opening 15.7, or slightly more than half length without caudal fin; total length of barbel 33.6, slightly less than total length of fish; length of illicium stem 6.1, of bulb 3, of stem of distal projection 2.9, of distal tentacle 1.1; longest upper fang 3; longest lower fang 3.6.

Illicium: A candle-like structure as in illustration. Bulb within a translucent sheath having a small anterior and larger posterior flange. and a distal projection. The latter consists of a pigmented basal stem longer than the bulb and a shorter unpigmented terminal filament.

Barbel: The structure is almost as long as the fish, consisting of a single, long, undivided stem, with small, short off-shoots scattered sparingly. The first very minute branch is 6.4 mm. from base. There are no more for a considerable distance, and then 8 irregularly spaced throughout the remainder of the brown pigmented portion, which extends from the base to within 5 mm. of the tip. These nine are all small. the largest only .54 mm. in length, about the diameter of the barbel itself. In structure they consist of a short stem ending in a round bulb. In the colorless, distal 5 mm., the branches are closer together, about 9 or 10 in all, with very slender stalks. In two, there are subsidiary divisions from one of the branches, there being 3 bulbs close together. The barbel ends in a small branch and bulb. The longest of these terminal and subterminal branchlets is 1.1 mm.

Teeth: In each half of upper jaw, 7 to 8 teeth, of which the first and third are longest. In each mandibular ramus 6 or 7, of which the first and fourth are largest. A pair of long, curved vomerine teeth, and a group of 5 or 6 upper pharyngeals on each side.

Fins: D. 3, A. 3, P. 17, C. 8.

Behavior: This fish lived for ten minutes after being taken from the net. Luminescence was observed as described above.

Remarks: Text-fig. 16 is to replace the illustration published with the type description.

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TEXT-FIG. 16. Linophryne arcturi (Beeke), holotype. A, Lateral view. B. Illicium.

Linophryne quinqueramosus sp. nov. (Plate III, Fig. 5; Text-fig. 17).

TYPE.

(The unique specimen). Department of Tropical Research No. 28,-709; Eastern Pacific Zaca Expedition; Station 234 T-1 (7° 24' N. Lat., 78° 35' W. Long.); 24 miles W \times S of Pinas Pt., Panama; 500 fathoms; April 4, 1938; total length 89 (62+27) mm.; ovaries minute with eggs scarcely developed.

DESCRIPTION.

With the characteristics of the genus.

Color: Jet black, except for white details of illicium and barbel, as noted below.

Measurements and Proportions: Snout to gill opening 36 mm., slightly more than half length of fish without tail. Illicium short, measuring 17.7 overall (stem 7.8, bulb 7.1, filament 2.8); longest barbel tentacles about 40; length longest fangs, upper jaw 7.5, lower jaw 8.2.

Illicium: The illicium arises from a deep groove on tip of snout, so deep that the base of this organ takes the place of the symphysis, the large upper teeth arising on each side. Stem short and thick, 15 mm. long, with a wide black basal zone, then a white band of equal width, followed by a second black area anteriorly. This stem expands abruptly, and encloses the blue black bulb. Distal to this posteriorly is a silver protuberance topped by a minute tubercle with a small longitudinal ridge or flange behind and below it. In front of the tubercle, on the distal ridge, is a tiny pore. From the anterior edge of the bulb sheath rises a flattened, transverse structure giving rise distally to a round, opaque, blunt finger, 7 mm. long; on the right side only of the base of this transverse structure are three minute tentacles.

Barbel: From the center of the throat there arise five long tentacles so close together that their bases touch. The proximal 10 mm. of the anterior pair are black; the remainder of this pair, all of the shorter central tentacle, and almost all of the posterior pair are translucent white. The details of the proportions and branching can best be seen from the figure. Each of the short tentacles ends in a shining, white, opaque bulbet, scarcely expanded.

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TEXT-FIG. 17. Linophryne quinqueramosus, holotype. A. Lateral view. B. Barbel, left lateral view. C. Dentition. Depressible teeth unshaded. D. Illicium, left lateral view. E. Illicium, posterior view.

Teeth: 12 or 13 teeth in each half of the upper jaw and in each mandibular ramus, including long fangs, replacement teeth, small teeth, and several minute fixed teeth. A pair of teeth on the vomer and a series of 4 or 5 upper pharyngeals on each side.

Fins: D. 3, A. 3, P. 16, C. 8. Food: The stomach was enormously distended with the following: 1 Serrivomer, 330 mm. long; 1 Sternoptyx, 25 mm.; 2 Cyclothone, 26 and 60 mm.; 5 shrimps, 12-30 mm.



TEXT-FIG. 18. A ceratias spp. A, Post-larval (Cat. No. 28,756, "a" in text). B. Transitional adolescent (Cat. No. 28,763, "h" in text). C. Same specimen as A, front view. D, same specimen as B, front view. Note asymmetrical development of papillae.

Remarks: This specimen is perhaps closest to *L. macrodon* Regan, 1926, also from the Gulf of Panama. It differs, however, in the shorter, distally distinct illicium, in the branching of the barbel, and in the larger number of teeth.

Aceratias spp. (Text-figs. 18, 19).

Ten specimens of young, free-swimming linophrynid males were taken in or near the Gulf of Panama. All have the general characters ascribed by Regan & Trewavas to *Aceratias*, having the characters of the family, no illicium or barbel, 3 to 5 rostral denticles united on a median bone, premaxillaries reduced to a pair of plates, jaws toothless or with only 1 or 2 on each side, and a well developed predentary bone bearing denticles in front of the lower jaw.

The genus at the present time, as revised by Regan & Trewavas, 1932, includes two species, *indicus* and *macrorhinus*, each obviously including more than one biological species, and probably more than a single genus. Parr, 1934, described an *Aceratias*form of male as *Borophyrne masculina*, because of its close resemblance to the attached males of *Borophryne apogon* recorded by Regan & Trewavas. On that basis, all of ours too are *Borophryne*, but until other genera, particularly *Linophryne*, can be shown to have a *Nannoceratias*-type, or other clearly marked form, as their male representative, we do not feel justified in referring any of this series to *Borophryne*.

We are convinced, on the other hand, that more is to be gained by treating all ten as a single series. No two are identical, and yet a specific definition could be formulated to embrace all, no broader than that which now defines A. *indicus*. The truth probably is that four or five species and at least two genera are represented.

Since Edriolychnus has been found to have a Haplophryne-type male (Regan & Trewavas, 1932), with many teeth in the jaws, and the attached males of Borophryne are obviously of the Aceratias-type, it is practically certain that some of the 10 young in the present series belong to that genus. It seems almost equally probable that Linophryne, and at least Acentrophryne in addition are represented, all three of these genera being known from the Gulf of Panama region where the present males were taken. Only one male attached *Linophryne* has so far been taken (Regan & Trewavas, 1932, p. 19), and this has not been described in detail. According to the authors, it resembles *Borophryne* closely, even to the sphenotic spines, but neither the number of lamellae nor the denticle formula is known.

Repeated efforts to divide the present specimens into genera have been unsuccessful. The work is complicated by the following considerations, in addition to the obvious prime one of paucity of material.

1. General macroscopic characters, including the obvious ones of fin, lamella, and denticle counts, show slight or no differences.

2. Macroscopic differences, such as amount of inflation and eye rotation, are merely growth characters.

3. Other apparent differences, especially in the shape of the inflated envelope, of nos-

trils and of rostral profile, as well as the frequent lack of cephalic symmetry, (especially in eye size), are apparently due to varying effects of preservation.

4. Fundamentally reliable characters taxonomically are still unknown, and will probably prove to be such microscopic details as shape of individual lamellae and denticles.

5. It must be kept in mind that in these males there are two forces at work: the usual one of growth and normal development, and the second, specialized force of degeneration, associated with parasitism. This is visible in our material, not only in the attached *Borophryne* males (see p. 172), but also in at least one (see below) of these free-swimming *Aceratias*. It seems probable that many individuals must fail to find females, in which case degeneration, at least of nostrils and eyes, proceeds unaccompanied by sexual development.



TEXT-FIG. 19. Aceratias spp. General types of lamellae. Each sample taken from middle of a series, where maximum development is attained. **A.** High, narrow type (from Cat. No. 23,761, "f" in text). **B.** Low, broad, split type (from Cat. No. 28,762, "g" in text). **C.** Very high, narrow type (from Cat. No. 28,763, "h" in text). **D.** High, curved, broad type (from Cat. No. 28, 764, "i" in text). In each, exterior tip is uppermost and anterior edge toward the right.

TABLE I.

ACERATIAS SPP.

Principal Differences in 10 Specimens Arranged According to Apparent Age.

(Note: Trawling and other data given under Study Material, p. 180; see text for further discussion).

	No. 28.756	No. 28.757	No. 28.758	No. 28.759	No. 28.760	No. 28.761	No. 28.762	No. 28,763	No. 28,764	No. 28,765
	("0")	(q,,,)	· ("o")	(,,p,,)	(,9,,,)	("f")	(" <i>b</i> ,,)	(4,.,)	(?,,)	(,,,,)
Inflation	Great	Great	Medium	Medium	Medium	Medium	Medium	Slight	Slight	Slight
Stand. lgth. in depth at P.	63 %	79 %	57 %	55%	50%	54%	54%	42 %	42%	48%0
Eye, rotation	Slight	Slight	Slight	Moderate	Moderate	Moderate	Moderate	Great	Great	Great
Eye-ball, diameter (% of largest)	75%	67 %	58%	62 %	79%	75%	71%	88%	100%	96 %
Denticles, sheathed ?	Mostly	Not	Partly	Not	Not	Mostly	Not	Not	Not	Not
Denticles, rostral	4	5	3	5	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	5	5	ۍ د	5	8
Denticles, predentary, r. lat.	4	3	3	4	4		00	4	en	4
Denticles, predentary, l. lat.	4	3	3、	4	33	0	4	9	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	4
Denticles, predentary, shape	Short, thin	Long, thin	Long, wide	Long, medium	Medium, stout	Short, stout	Long, stout	Short, medium	Long, stout	Short, stout
Denticles, median predentary, shape	Short, thin	Broken <mark>?</mark> Points down ?	Long, thin	Long, thin	Medium, stout	Medium, stout	Long, stout	Short, thin	Long, stout	Long, stout
Teeth, upper, r.	0	Jaw serrations	0	0	0	0	0	0	0	0
Teeth, upper, l.	0	Jaw serrations	0	0	0	0	0	2	Several	0
Teeth, lower, r.	1	Jaw serrations	2	0	0	0	2	0	0	0
Teeth, lower, l.	2	Jaw servations	0	0	0	0	0	0	0	0
Lamellae, number	6	8	6	6	6	6	6	6	6	8 or 9
Lamellae, shape (Text-fig. 19)	Low, broad, solit	High, narrow	High, narrow	High, curved, broad	Low, broad, split	High, narrow	Low, broad, split	Very high, narrow	High, curved, broad	Low, broad, split
Lat. Line System Papillae	Tiny, few	Tiny, few	Tiny, few	Tiny, few	Small	Medium	Tiny, few	Well developed	Tiny, few	Small
Mental fringe	Rudinentary	None	None	None	None	Present	Present	Present	No	No
Sphenotic spines, lgth., subdermal incl.	Medium	Short	Medium	Medium	Medium	Medium	Medium	Rudimentary	Medium	Long

Since profitable subdivision is not at present possible, the 10 young males are arranged in Table I in order from the apparently youngest to the apparently oldest. However, since various species are involved, the arrangement is only for convenience, and does not represent a truly linear sequence. The characters listed indicate the chief differences both of development and also those which are most likely to prove of taxonomic value. For the present discussion the specimens are lettered for easy reference. Corresponding catalogue numbers, with complete field data, will be found under Study Material. The entire series will be loaned on request to any investigator working on other collections.

In the following paragraphs, the likenesses, differences due apparently to growth, and differences probably of taxonomic importance, are summarized.

A. Similarities.

All 10 agree in the following respects:

1. Size: The range is only from 17.4 (11.1+6.3) to 21.3 (14.4+6.9) mm. The smallest and the largest are the two youngest specimens.

2. Lack of Pigment: Subdermal chromatophores are completely lacking, and only one example, h, has readily discernable external pigment; this consists of a faint wash of brown.

3. General Denticle Arrangement: 3 to 5 rostral; 3 or 4 predentary plus a median; sometimes 1 or 2 jaw teeth on either or both sides.

4. Nostril Form: Both fairly small, on a distinct prominence, with the jutting rostral eminence between. The anterior smaller, elongate, fairly close to the posterior; the latter at a considerable distance in front of the eye.

5. Lamellae Count: 9 except for b, which has 8, and j, which possibly has only 8. In the latter case the lamellae appear to be breaking down (preparasitic degeneration through failure to find female?); the specimen is well preserved.

6. Fin Counts: D. 3, A. 3, C. 1+3+3+1, P. 15-17.

7. Sphenotic Spines: Present, though of variable length, in all.

8. General Body Proportions: Excluding the highly variable depth, the general proportions and fin positions appear very similar, although these measurements, as usual in pediculates, are highly unsatisfactory.

B. Differences Due to Age.

The following distinctions we attribute to normal development pattern. Those assigned as characteristics of the youngest are found in fish which show the obvious, ichthyological youth characters of persistence of vestigial finfolds near the vertical fins and imperfectly differentiated pectorals. It must be kept in mind that adequate life history data will doubtless show some of these characters to have specific as well as developmental significance. For example, though young animals are more inflated than old ones, some species will probably prove to show more inflation than others. The series on the basis of previously established definitions (see p. 151) may be divided into post-larvae, adolescents and transitional adolescents.

1. Amount of Inflation: The depth at pectoral fin ranges from almost four-fifths of the standard length in the youngest to less than half standard length in the oldest. (Standard length here is measured to end of myomeres, as seen by indirect lighting).

2. Sheathing of Denticles: Some of the younger have denticles skin-covered throughout much of their length.

3. Teeth in Jaws: It seems likely that these long, thin, loosely inserted, asymmetrical structures are temporary teeth, remaining from the larval stage, such as are found in other groups of fishes.

found in other groups of fishes. 4. Size of Nostrils: The nostrils are smaller in younger fish, although the full quota of lamellae is present. Only 2 or 3 of the typical 9 are visible in the posterior orifices of younger, and around 6 in those of older specimens.

5. Rotation of Eye: In the youngest three, the eye is almost normal, scarcely turned; in the oldest three, it is revolved strongly forward and down. Intermediate specimens show intermediate grades of rotation.

show intermediate grades of rotation. 6. Diameter of Eyeball: The actual size of the eyeball is distinctly larger in the oldest specimens, although specific differences are also probably involved. The regular eye diameter measurement appears, as usual in pediculates, to be totally useless.

7. Lateral Line System Papillae: In all except several of the older specimens, the papillae are few, rudimentary, and practically indistinguishable.

8. Sphenotic Spines: These spines, although well developed in all, scarcely protrude beyond the dermal envelope in the youngest.

C. Differences of Probable Taxonomic Value.

It appears highly probable that the following characters will prove of specific and/or generic value.

1. Number of Rostral Denticles: Six specimens have 5, 1 has 4, and 3 have 3 denticles each. However, at least in the case of a, having only 4, the fifth is clearly either to be developed or accidentally lost. Similarly, in the cleared and stained attached Borophryne (p. 172), 4 are present, with a degenerated (?) stump of a fifth. Regan & Trewavas' attached *Borophryne* each had 5 denticles (1932, p. 18).

2. Shape of Forwardly Directed Median Predentary Denticle: Varies from short and thick to long and slender.

3. Shape of Paired Predentary Denticles: From triangular to slender; not correlated with shape of median.

4. Shape of Individual Lamellae: In one type (a, e, g, j), including both young and old individuals, each lamella appears double, like adjacent sections of orange, the two halves joined along a seam which tends to split. In another (h) the lamellae are elongate, the attached edge being the shorter.

5. Lateral Line System Papillae: In some older specimens, these tags in the future may furnish good taxonomic distinctions, although there is variation even in the attached Borophryne males (p. 172). Only in f and h of the present series are they moderately well developed.

6. Mental Fringe: In specimens a, f, g and h, there is a tiny, superficial, anomalous, variable, fringe-like structure corresponding in position to the base of the barbel in Linophryne females; f and h have in addition similar appendages in the midline of the top of the head, well behind the level of the sphenotic spines. Perhaps all of these merely represent irregularities in the lateral line papillae, which are highly variable in both sexes of the family Linophrynidae. However, the position of the mental fringes, because of their similarity to that of the *Linophryne* barbel, justifies special notice of their occurrence. As will be seen from the table, the four fish involved do not appear to be linked by other special characters, such as denticle peculiarities.

7. Length and Shape of Sphenotic Spines. The actual length of these spines is quite variable, irrespective of the length protruding externally from the envelope, and should prove to have some taxonomic significance. They also show varying degrees and directions of curvature, even on the two sides of the same individual.

STUDY MATERIAL.

All were taken on the Eastern Pacific Zaca Expedition.

a. Cat. No. 28,756; Sta. 225 T-1; 11 mi. SW \times W of Jicaron I., Panama (7° 08' N. Lat., 81° 57' W. Long.); 500 fathoms; Mar. 20, 1938; post-larva; length 17.6 (11.5+6.1) mm.

b. Cat. No. 28,757; Sta. 227 T-1; 20 mi. S.W. of Morro de Puercos, Panama (7° 00' N. Lat., 80° 40' W. Long.); 500 fathoms; Mar. 21, 1938; post-larva; length 17.4 (11.1 +6.3) mm.

c. Cat. No. 28,758; Sta. 230 T-1; 71 mi.

W \times S of Cape Corrientes, Colombia (5° 10' N. Lat., 78° 42' W. Long); 500 fathoms; Mar. 26, 1938; post-larva; length 21.3 (14.4 +6.9) mm.

d. Cat No. 28,759; Sta. 227 T-1; in same net with b; adolescent; length 18.7 (12.0 +6.7) mm.

e. Cat. No. 28,760; Sta. 227 T-1; in same net with b; adolescent; length 19.7 (12.7 +7) mm.

f. Cat. No. 28,761; Sta. 230 T-1; in same net with c; adolescent; length 19.5 (12.5 +7) mm.

g. Cat. No. 28,762; Sta. 230 T-1; in same net with c; adolescent; length 18.9 (12.4 +6.5) mm.

h. Cat. No. 28,763; Sta. 230 T-1; in same net with c; transitional adolescent; length 17.7 (11.5+6.2) mm.

i. Cat. No. 28,764; Sta. 225 T-1; in same net with a; transitional adolescent; length 20.3 (12.3+8) mm.

j. Cat. No. 28,765; Sta. T-8; 20 mi. S. of Cape Blanco, Costa Rica (9° 12' N. Lat., 85° 10' W. Long.); 500 fathoms; Feb. 27, 1938; transitional adolescent; length 18.7 (11.2+7.5) mm.

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PARR, A. E.

REGAN, C. T.



FIG. 1.



FIG. 2.



FIG. 4. DEEP-SEA CERATIOID FISHES.



FIG. 5. DEEP-SEA CERATIOID FISHES.